Mosquito Control Plan

I. Introduction

The safest, most effective mosquito and arbovirus control programs are based on the practice of Integrated Pest Management (IPM). The basic theory behind IPM is to base control decisions such as target area, time of application, and control method on surveillance findings and knowledge of the pest, and to apply the best and most appropriate control method(s) or pesticide(s) for each situation. By employing a range of different control methods and pesticides, technicians can deal with various species of mosquitoes during all stages of their life cycle. IPM methodologies also decrease the development of pesticide resistance by minimizing reliance on any one type of pesticide/mode of action, and by minimizing the frequency and volume of application through appropriate targeting.

The way each IPM component is utilized should be tailored to best meet the particular public health needs of each affected locality. The application of pesticides for mosquito control should be a local decision based on local surveillance data and knowledge of local conditions (see Section E. below for recommended response levels). To be effective, control activities must be directed towards the specific target mosquito species (see chapter on mosquito surveillance for further details). Therefore, surveillance will be needed to identify local mosquito populations and the specific biology and habits of the target mosquitoes must be well understood. Information on the biology and behavior of some of the known and suspected WNV vectors is provided in Attachment 4.A.

A. General

In Virginia, mosquito control activities are the responsibility of the jurisdiction in which they are required. Section 32.1-187 of the *Code of Virginia* (1950), as amended, provides that counties, cities, and towns may create mosquito control districts. Because of the substantial threat posed by West Nile Virus (WNV) to humans and domestic and wild animals, localities are encouraged to provide additional support to active mosquito control districts, and to establish mosquito control programs in localities where such programs do not currently exist.

State and local government agencies should provide citizens with information for managing mosquitoes on their properties. As the first line of defense against mosquito-borne disease, Virginia citizens should eliminate or treat mosquito-breeding sites on their own property. Governmental agencies should undertake water management projects on local, state, and/or federal lands where practicable. These projects should include drainage maintenance of ditches and other man made structures that may collect temporary bodies of water, removal of artificial containers that may catch and hold rainwater, larvicidal treatments of habitats that cannot be drained, removed or otherwise changed, and the stocking of mosquito eating fish into certain habitats. County or city governments should also enact and enforce ordinances pertaining to accumulations of

artificial containers (e.g., tire piles, junk, stored materials, abandoned swimming pools, etc.) that occur on private property, collect water, and serve as a source of local mosquito populations.

Adequate control of immature and adult mosquitoes may require the application of insecticides. The decision to initiate insecticide use should be based on an evaluation of its benefit by state and local authorities. When choosing insecticides, preference should be given to effective products or chemicals that are least toxic to humans and the environment. Commercial applicators that apply insecticides for mosquito control must be certified in Public Health Pest Control (Category-8) in accordance with the *Virginia Administrative Code*, sections: 2VAC20-51-10 through 2VAC20-51-90 (Regulations Governing Pesticide Applicator Certification). These regulations are available through the Virginia General Assembly website [http://legis.state.va.us/Laws/AdminCode.htm].

II. Objective

The objective of the mosquito control plan is to provide mosquito control guidelines for the reduction or prevention of WNV transmission to humans and their domestic animals by mosquito vectors.

III. Implementation Plan

A. Non Insecticidal Control

1. **Source Reduction** - The alteration or elimination of mosquito larval habitats is the most effective and economical method of providing long-term mosquito control. Through education and public information releases, state and local governments will provide technical assistance and encourage citizens to participate in source reduction through the removal of used tires, cleaning of rain gutters and bird baths, emptying or treating unused swimming pools, draining or dumping other artificial water containers, unclogging ditches, punching holes in tires used as play ground equipment, and otherwise eliminating potential mosquito breeding sites around the home.

   State and local government agencies responsible for the maintenance of ditches, streams and stormwater basins on public land should remove tires and other refuse and otherwise maintain these areas in such a manner that they do not become mosquito larval habitats. Standing water in ditches along state roads should be reported to the Virginia Department of Transportation (Tel. 800-367-7623). Problems with mosquitoes breeding in storm water retention ponds should be brought to the attention of the locality's regulatory/maintenance agency such as the local Department of Public Works. In salt marshes, ditch plugs and other water control structures should be removed or modified to permit daily tidal inundation to occur. The daily tidal exchange eliminates mosquito breeding and eventually restores the area to a productive salt marsh. Open Marsh Water

Management, which includes the selective excavation of ponds, pond radials, and ditches, is effective in eliminating mosquito breeding sites and providing permanent habitat for mosquito-eating fish. **Note:** Many of these activities in wetlands will require coordination with, and permitting by the district office of the U.S. Army Corps of Engineers and/or the regional office of the Virginia Department of Environmental Quality. Army Corps of Engineers District Offices for Virginia are listed at www.usace.army.mil/where.html; regional DEQ offices are listed at www.deq.state.va.us/regions/homepage.html. Many ditch maintenance activities are exempt from federal and state wetlands regulations, provided that the cross sectional area of the ditch is not modified. However, draining or excavating in wetland areas are regulated activities, and may require federal and/or state permits.

2. **Natural Predators -** Where appropriate, localities may introduce fish, such as mosquito fish (*Gambusia affinis*) into mosquito breeding habitats to control mosquitoes. Habitats where fish may be used to control mosquitoes include storm water retention ponds, stagnant ditches, backyard ornamental ponds and other man-made or artificial pools of water (residential/municipal). Other fish species, such as fathead minnows, freshwater killifish, certain species of sunfish and even the small fry of game fish (e.g., bass) may also be used to control mosquito larvae and pupae. Care should be taken to avoid stocking mosquito fish into areas that harbor game fish, as many larva-eating fish will also feed on game fish fry. County and city governments, or the mosquito control programs within these jurisdictions must obtain authorization from the Virginia Department of Game and Inland Fisheries (VDGIF) to collect and/or stock mosquito fish (Contact: Becky Wajda [pronounced Vida], Assistant Director, VDGIF Division of Wildlife Diversity; 804-367-8351). Jurisdictions having permits to use mosquito fish can obtain these fish for stocking from a hatchery operated by the York County, VA, Mosquito Control Program (contact James Rindfleisch at 757-890-3790).

3. **Avoidance of Adult Mosquitoes by the Public** - Through public service announcements and other means of outreach, citizens should be advised to install screens on windows and doors of homes and commercial buildings. They should also be advised to protect themselves by: avoiding outdoor areas during times when mosquito populations are actively feeding; wearing hats, socks, and loose fitting, light colored clothing with long pant legs and long sleeves when outdoors; and using mosquito repellents containing deet, and following safe repellent use practices (Attachment 4.B).

B. The Use of Insecticides - General

1. Notification: If it becomes necessary to use insecticide fogs/aerosols for

area control of adult mosquitoes, local governments should provide residents with accurate and precise advance information on when and where these pesticides will be applied so that citizens who wish to avoid exposure may take cover and/or take action to protect pets and domestic animals including managed honeybee colonies, and aquaculture projects. Among various methods of informing the public, such as the media, one of the easiest ways to provide this advance notice is to establish a telephone hotline, publicize its number and record daily updates. Broad scale, aerosol/fog insecticide applications that cover areas that have not been surveyed or determined to have active mosquitoes, are not in keeping with prudent IPM practices. Targeted, focused and limited aerosol/fog application should be based on sound, scientific surveillance indicators.

2. Safe Use of Insecticides: A list of insecticide active ingredients registered for both larval and adult mosquito control in Virginia is provided in Attachment 4.C. The use of insecticides for mosquito control may be accompanied by risks to non-target organisms including humans. Direct toxicity is the primary concern, and may be reflected in fish or wildlife kills or in episodes of non-lethal effects that render exposed non-target organisms susceptible to other sources of morbidity or mortality. Pesticide application personnel, in particular, are at risk from direct toxic effects of insecticides, and proper precautions must always be taken when handling, mixing and applying pesticides. Equipment used for applying pesticides must be properly calibrated to dispense the pesticide according to label specifications. Whenever any pesticide is applied, the law requires that the directions outlined on the pesticide label be carefully followed. When choosing insecticides for mosquito control, governmental agencies and their contractors should give preference to those products that pose the least risk to humans and the environment. Environmentally friendly insecticides are generally the most effective in the long run because they help preserve many of the natural enemies that help regulate the size of mosquito populations. The relative risks (toxicity) associated with the currently registered mosquito control insecticides, both larvicides and adulticides are discussed in Attachment 4.C.

Note: Any fish kills must be reported immediately upon discovery. During business hours contact the closest regional Department of Environmental Quality office; otherwise contact the Department of Emergency Management at 1-800-468-8892.

C. Use of Insecticides for Larval Control

1. Larval mosquito control targets immature mosquitoes in their aquatic habitat before they become flying, biting adults. In general, larval control is the most effective method of controlling some mosquito populations, has the least effect on non-target species, and is applied to the smallest area of the environment. For example, one can treat an acre of aquatic habitat to

control mosquito larvae, but if one waits until the adults have emerged and dispersed, one may need to treat 500 acres to kill the adults that emerged from that acre of habitat. Localities may conduct their own larviciding activities, or contract with commercial pesticide applicators to conduct larviciding operations. Larvicides may be applied by hand, or with powered backpack mounted, vehicle mounted or aircraft mounted equipment. Aircraft application of larvicides is most practical when large areas of inaccessible terrain need to be treated quickly. The larvicides that can be used for mosquito control in Virginia include the following:

a. Bacterial larvicides such as *Bacillus thuringiensis* var. *israelensis* (a toxin from a killed bacteria), and *Bacillus sphaericus* (a live bacterial spore) can be used successfully in a broad range of freshwater habitats, but are somewhat unpredictable in salt marsh habitats. *Bacillus thuringiensis* (***Bt***) based larvicides are sold in a variety of formulations (liquid, granule or briquet) under a wide variety of trade names such as: Mosquito Dunks®, VectoBac™, Aquabac™, Bti Briquets™. ***Bt*** based larvicides are quite effective against members of most mosquito genera, but may be slightly less effective on members of the *Culex* genus. *Bacillus sphaericus* (***Bs***) based larvicides are sold under the trade name VectoLex™. ***Bs*** is highly effective against species in the *Culex* genus, but is not effective against Asian tiger mosquitoes and several other species of *Aedes* and *Ochlerotatus* mosquito species. ***Bs*** works very well in polluted water, where it may be self-perpetuating. Bacterial larvicides are most effective when used against mosquitoes in the 1st through 3rd larval growth stages, but will not control late 4th stage or pupal stage mosquitoes.

b. Biochemical larvicides contain an insect growth regulator called methoprene and are sold under the trade name Altosid®. Methoprene is an insect hormone mimic that prevents immature mosquitoes from developing into adults. Altosid® products are labeled for use in a wide variety of natural and artificial aquatic habitats and are effective for use in salt marshes. Altosid® is relatively target specific and will not harm many aquatic species such as amphibians or aquatic insects having incomplete metamorphosis (e.g., water bugs, damselflies, dragonflies). However, it may be slightly to moderately toxic to some fish species and is toxic to crustaceans such as shrimp or crab species or aquatic insects with complete metamorphosis (e.g., flies, beetles). Altosid® may be somewhat toxic to birds which consume granules that land on dry ground. Altosid® is most effective when used against mosquitoes in the 1st through early 4th larval growth stages, but is not effective against late 4th larval stage or pupal stage

mosquitoes.

c. Monomolecular surface film larvicide (trade name - Agnique®) is sprayed on water to prevent immature mosquitoes from attaching their siphon tubes to the water surface to breathe. Monomolecular surface films (MSFs) are often used when surveillance indicates that a large proportion of the immature mosquito population has reached the 4th larval stage and the pupal stage; late 4th stage larvae and pupal stage mosquitoes are resistant or immune to control with microbial or biochemical larvicides. MSFs can be highly effective in puddles, ditches, and other artificial and natural habitats, and in polluted water. MSFs work best on small, sheltered bodies of water, and may be rendered ineffective (blown off the surface) in habitats exposed to excessive wind. Their effectiveness is also reduced in areas of heavy aquatic vegetation. MSFs are inert and will not pollute aquatic environments or harm aquatic organisms such as fish, amphibians, or crustaceans. However, MSFs can harm populations of small aquatic arthropods (e.g., spiders, water striders, etc.) that rely on water surface tension for locomotion or respiration.

d. Surface Oils (Mineral Oils) (sold under trade names such as BVA Oils™ or Golden Bear Oil™) are sprayed as a layer on top of water to suffocate and drown larval and pupal mosquitoes. Surface oils are less affected by wind than monomolecular surface films and are effective in habitats with heavy emergent vegetation. Oils are mostly used when immature mosquito larvae have developed to a stage beyond which other larvicides will control them. Unlike monomolecular surface films, oils are not inert and so they may affect some non-target aquatic organisms. Use of oils on water in environmentally sensitive areas should be avoided. Where possible, the use of oils should be limited to artificial containers, puddles, ditches, and other un-natural habitats.

e. Chemical Larvicides: An organophosphate insecticide called Temephos is the only chemical insecticide sold for control of mosquito larvae. Temephos is sold under the trade name Abate®. Abate® can be effective in the treatment of puddles, artificial containers (tire piles), and polluted waters high in organic content. Abate® is very effective for controlling-mosquito larvae, but might also impact fish, amphibians, aquatic arthropods and other aquatic organisms, particularly when label rates are exceeded. Therefore, its use should be avoided in environmentally sensitive areas and limited to artificial containers, puddles and other un-natural habitats.

Misuse of chemical insecticides such as Abate® in semi-permanent, artificial and natural habitats (e.g., storm water settlement ponds, semi permanent ponds and wetlands) may impact important predators and natural enemies in the habitat. Elimination of the natural enemies that helped keep the initial mosquito population in check, facilitates a heavy resurgence and re-colonization of that habitat by mosquitoes and can lead to a dependence on the continued use of larvicides in that habitat..

D. Use of Insecticides for Adult Mosquito Control

1. **Techniques of Adult Mosquito Control -** Adult control consists of two different methodologies. One methodology is known as "the application of "Ultra Low Volume (ULV) aerosols" and/or "fogging". The other methodology is known as the application of "barrier treatments".

2. **Aerosol or Fog Applications for Adult Mosquito Control** – Aerosol/fog applications are the most widely used method of adult mosquito control and involve a volumetric treatment of air by the dispersal of very fine aerosolized droplets that are light enough to float on the air and be carried over a large area by wind. These small droplets (generally ranging from 1 to 40 microns in size) float on air currents and intoxicate the flying mosquitoes that are impacted by them. Fogs/aerosols are dispensed in very low doses (ounces per acre) and do not leave any significant residual pesticide layers on surfaces within treated areas. Aerosols and fogs generally only kill mosquitoes that are in flight because mosquitoes that are resting in sheltered areas are not impacted by sufficient numbers of droplets to get a toxic insecticide dose.

    a. Ultra Low Volume (ULV) fogs and aerosols are generated with dispensing machines that physically split a liquid insecticide into very small droplets of a relatively uniform size (narrow size range). Most ULV machines can be set to produce droplets of a particular size within the 1 to 50 micron size range. The production of ULV aerosols/fogs does not require that the liquid insecticide concentrate be mixed with a carrier liquid such as oil or water, so a very small volume (ultra low volume) of liquid insecticide can be converted into a fog/aerosol of relatively pure insecticide and be dispensed over a wide area.

    b. Thermal fogs are generated with thermal fogging machines that heat the liquid insecticide during the process of breaking it into small droplets. Thermal fog droplet sizes may range from 1 to 50 microns, with a large portion of the droplets being in the 10 to 15

micron (visible) size range. Droplets within this size range scatter light and therefore appear as a white cloud. Insecticides dispensed by thermal foggers must be mixed with a carrier liquid such as oil, so thermal fog applications require more liquid volume per the quantity of insecticide dispensed.

c. Fogs and aerosols are essentially the same thing, but vary slightly in definition. A fog is a visible aerosol because it consists a large portion of small droplets in the 10 to 15 micron, visible size range. An aerosol is a general term that describes air borne droplets in a variety of sizes from visible, fog-sized, droplets to larger, less visible droplet sizes in the 15 to 40 micron size range. A fog is an aerosol, but an aerosol is not necessarily a fog. The difference between these two terms is technical and for practical purposes, most personnel involved in mosquito control refer to aerosols generated by both ULV machines and thermal foggers as fogs, and refer to both types of machines as foggers. Aerosol droplets in the 40 to 100 micron size range do not float in the air for very long, and can leave a wet residual layer on any solid surfaces they encounter. These larger sized droplets are considered to be a mist.

d. Application of mosquito adulticide aerosols/fogs should be considered and evaluated on a case-by-case basis. Mosquito control response levels for WNV control (see Section E., Level I-b through V, below) are based on local levels of vector mosquito activity and arboviral activity and may aid in determining when to apply adulticides. However, this judgment can only be made based on local surveillance data and knowledge of local conditions (e.g., human population density, detected levels of arboviral activity, target mosquito species, mosquito population density, layout of local roads or other geographical features, weather forecast, prevailing wind directions, etc.). Mosquito aerosol and fog applications should be made using properly maintained and calibrated ULV machines and foggers. Adulticide aerosol/fog applications may be made by equipment that is hand held, or mounted on backpacks, all terrain vehicles, trucks, or on fixed-wing or rotary-wing aircraft.

e. Aerial applications of mosquito control insecticides are useful for rapidly treating large areas that cannot be easily accessed or covered in a timely manner by ground based spraying equipment. Due to the speed of coverage, the large area that can be treated, and the uniformity of the coverage, aerial applications are more effective in controlling mosquitoes than ground-based applications. Aerial applications may be recommended when there is a widespread and imminent threat from mosquitoes infected with and

arbovirus such as WNV (see Section E., Response Level V, below). Depending on the configuration [shape] and size of the area to be sprayed, one may need to consider the advantages and drawbacks of using either fixed-wing or rotary-wing aircraft for dispersing insecticides.

Aerial applications of pesticides require much advanced planning to identify the areas that should be treated, identify the areas to be avoided, and to properly notify or warn populations and businesses (e.g. beekeepers, aquaculture farmers, food preparation facilities) within the proposed spray area. Properly certified applicators must be aboard each aircraft that is conducting aerial pesticide applications. State and local public health and other governmental agencies may establish pre-existing requirement contracts with commercial pesticide applicators that can be activated on a moments notice when wide-area mosquito control becomes necessary. When natural disasters such as floods and hurricanes increase the potential for arthropod-vectored disease transmission over large areas, exceeding the capability of local and state resources to respond in a timely manner, the state may request assistance from FEMA for emergency funding for contracting aerial mosquito control operations and/or may request assistance from the Department of Defense for aerial application of mosquito control pesticides on Federal land by the U.S. Airforce.

f. Timing and conditions for adulticide aerosol/fog applications must be appropriate for treatments to be effective. Depending upon the target species, the greatest efficacy will be achieved when applications are made during periods when the target species is in flight. For example, *Culex pipiens*, a primary vector of WNV, is a nighttime biter, and applications should be made starting at dusk and continuing into the nighttime hours. The fogging of daytime flying mosquitoes can be problematic. Aerosol/fog applications made during daylight hours are often ineffective because warm convective air currents rising from close to ground level will carry the fine aerosol/fog droplets up into the sky. Daylight fog applications can be effective only when there are no convective currents and this may occur during early morning hours, on overcast days, or in heavily shaded areas. Fogging applications should be made when air temperatures are above 50° F because mosquitoes will not fly at lower temperatures. It is preferable to make fogging applications when wind speeds are from 3 to 5 mph. To avoid poor pesticide coverage due to excessive pesticide drift and dilution, fog applications should not be made when wind speeds exceed 10 mph. Applications should not be made from either ground vehicles or aircraft during periods of dead calm because the

fog/aerosol will not be carried from the road or aerial spray swath into target areas.

3. **Barrier Treatments for Adult Mosquito Control –** Barrier treatments involve the application (spraying) of residual liquid pesticides on surface areas. A residual pesticide barrier applied to a surface can kill adult mosquitoes that subsequently land on the treated surfaces. Depending on the surface treated, and the occurrence of rain or other factors that might degrade a residual insecticide layer after treatment, residual barrier treatments may be effective for several days to several weeks after application. Barrier treatments are applied to foliage, vegetation, the eaves, ceilings and walls of houses, or any other place where adult mosquitoes are known to land and rest. Barrier treatments may be applied using a simple liquid insecticide sprayer with a fan nozzle, or may be applied using a ULV machine, thermal fogger, or air-blast fogger set to dispense mist-sized droplets in the 40 to 100 micron size range. Portable ULV machines are best used to apply barrier treatments to plants and foliage because relatively small quantities of insecticide can be used to apply a uniform layer of insecticide on a large area of foliage.

4. **Insecticides Used for Adult Mosquito Control** – The products currently registered in Virginia for adult mosquito control include insecticides in the organophosphate, and synthetic pyrethroid classes as well as pyrethrins. Some of the commonly used insecticides currently registered for use as mosquito adulticides in Virginia are listed in Attachment 4.C. Each of these insecticides has advantages and drawbacks as well as label specifications that will influence which material is most appropriate for a given situation (Attachment 4.C). Considerations should always be made on the adverse impact to non-target species and potential for detrimental health effects on sectors of the human population. Localities seeking additional guidance on appropriate mosquito control pesticides should contact: the Virginia Cooperative Extension at Virginia Polytechnic Institute and State University, Blacksburg, Virginia, Tel. (540) 231-6543; Dr David Gaines, Public Health Entomologist for the VDH-Office of Epidemiology, Tel. (804) 786-6261; or Dr. Marvin Lawson, VDACS-Office of Pesticide Services, Tel. (804) 786-3534.

E. Recommended Response Levels for Mosquito Control Operations in response to the threat of WNV

1. **Level I-a** – Winter weather, low likelihood of WNV epizootic activity, and little or no adult mosquito vector activity present.

   Plan and organize mosquito control program elements for larval and adult

control. Identify habitats where larval control measures can be applied. Scout and identify locations where drainage/source reduction activities could be applied and identify areas that might require larvicidal control methods once the mosquito season commences. If resources are available, conduct ditching and other source reduction operations.

2 **Level I-b** – Mosquito breeding season, adult mosquito activity present, no current evidence of WNV epizootic activity.

Where appropriate and resources permit, conduct ditching, drain cleaning, filling of ruts, and other habitat modification activities for source reduction. Conduct larval control of vector species in identified breeding habitats where source reduction (habitat modification) is not possible. Consider adult mosquito control where large primary vector populations are detected. Implement an education/media campaign to encourage citizens to eliminate container breeding habitats around their homes.

3. **Level II** - Mosquito larvae and adults present, initial evidence of WNV epizootic activity (limited to birds and/or mosquitoes).

Where resources permit, conduct programs for larval control in key problem mosquito habitats, continue and enhance source reduction and public education programs. Target larval vector populations and consider use of adult vector control tactics in areas where WNV activity has been detected, and adult vector species have escaped larval control.

4 **Level III** – Moderate WNV epizootic activity in mosquitoes and birds with initial evidence of WNV in a horse or human.

Continue, source reduction and public education programs and enhance larvicide programs to target vector breeding habitats in areas of increased WNV epizootic activity. Consider use of adult control tactics in areas where vector species have escaped larval control and where evidence of WNV has occurred. Plan an emergency mosquito control program to be ready if conditions ever reach a state where such operations are needed.

5 **Level IV** – Heavy WNV epizootic activity suggesting high risk of human infection (i.e., high dead and/or positive bird densities, high mosquito infection rates). Confirmed human or horse case, abundant adult bridge vectors.

Conduct larval mosquito control and strongly consider use of adult mosquito control tactics targeted at vector populations. Increase control efforts in areas of potential human risk

6 **Level V** – Multiple human cases of WNV and conditions favoring further transmission to humans.

Implement emergency larval control and strongly consider use of adult mosquito control tactics. If outbreak is widespread, covers multiple jurisdictions, and mosquito populations originate from large habitats inaccessible to ground vehicles, consider conducting aerial application of larvicides and adulticides targeted to known and potential areas of vector mosquito activity.